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MASSACHUSETTS INSTITUTE OF TECHNOLOGY

APOLLO

GUIDANCE AND NAVIGATION

Approved: Milton B. Trageser Date: 8/12/63
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R-348 (Rev. B)
Specification for Procurement
of Apollo Inertial Reference
Integrating Gyro
by
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INSTRUMENTATION LABORATORY
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SPECIFICATION
FOR
PROCUREMENT OF
APOLLO INERTIAL REFERENCE INTEGRATING GYRO
INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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SPECIFICATION
FOR
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APOLLO INERTIAL REFERENCE INTEGRATING GYRO
INSTRUMENTATION LABORATORY
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1. SCOPE

1.1 Scope of this Specification

This specification establishes the requirements for the procurement of the Inertial Reference Integrating Gyro (MIT/IL D105306) (hereafter called the IRIG) designed for use in the Apollo Guidance and Navigation System.

2. APPLICABLE DOCUMENTS

2.1 Specifications for the Production of IRIGs

2.1.1 MIT/IL Specifications

MIT/IL drawing D 105306 and those drawings which are referenced by it and its subassemblies, together with appropriate parts lists and the MC specifications (MIT/IL document E-1091) define the gyro design for this specification. Report R-349, as applicable to the gyro, specifies the Reliability and Quality Control program.

2.1.2 Government Specifications

NASA Quality Assurance Documents 200.1, 200.2 and 200.3.

2.2 Conflicting Requirements

In the event of conflict between the requirements of the contract, this specification, and other specifications and drawings cited herein, the requirements of the contract, this specification, and the documents listed in this section, shall govern, in that order.

2.3 Procurement of Applicable Documents

Copies of specifications, standards, drawings, and publications required by the contractor in connection with specific procurement functions should be obtained from MIT/IL.

3. REQUIREMENTS

3.1 General Requirements

3.1.1 Materials

The materials used in fabricating the IRIG shall be in strict accordance with applicable drawings and specifications referenced in section 2.

3.1.2 Construction and Assembly

The construction of the IRIG shall be in strict accordance with applicable drawings and specifications referenced in section 2.

3.1.3 Workmanship

The fabrication and finish of the IRIG, its assemblies, subassemblies, and parts shall be such as to produce a unit free from any defect that would affect proper functioning in service.

3.1.4 Serial Numbers

Each IRIG shall be identified by a serial number assigned by the NASA. Vendors shall request assignment of serial numbers from the procuring activity.

Unauthorized use of NASA serial numbers other than those issued by the NASA is prohibited.

3.1.5 Interchangeability

Unless otherwise specified, the IRIG and its component parts shall be physically and functionally interchangeable without selection or fitting within the tolerances of this specification.

3.1.6. Service Life

3.1.6.1 Operating Life

The IRIG design is intended to meet performance specifications for at least 5000 hours of gyro wheel operation, including the manufacturer's turntable testing time of the completed unit.

3.1.6.2 Shelf Life

The IRIG design is intended to have a shelf life at least three years, without operation, at ambient room temperatures after final acceptance at the vendor's plant.

3.1.7 Reliability

This section is inserted to provide for the inclusion of future reliability considerations as they may occur. The present known objective for the reliability of stable drift characteristics of gyros covered in this specification is three years.

3.2 Acceptance Tests

3.2.1 Classification of Acceptance Tests

The Acceptance Tests are to be performed on all IRIG's being submitted for acceptance under the contract. Acceptance Tests shall be performed by the manufacturer and may be witnessed by an MIT/IL Representative, an authorized Representative of MIT/IL, or a NASA Representative. These tests are detailed in paragraph 4.2.

Acceptance Tests are broken down into two categories as follows: Functional Tests which are designed to measure the functional parameters of the IRIG, and Performance Tests which are designed to measure the basic performance characteristics of the IRIG as a precision instrument.

I Functional Tests (see 4.2.2)

1) Thermistor Calibration (see 4.2.2.1)
2) Ducosyn Resistance Checks (see 4.2.2.2)
3) Magnetic Suspension Centering Test and Current Phasing Adjustment (see 4.2.2.3)
4) Wheel Operation Test (see 4.2.2.4)
5) Angle-Voltage Sensitivity Test (see 4.2.2.5)
6) Input Axis Polarity Test (see 4.2.2.6)
7) Limit of Equivalent Angular Rotation (see 4.2.2.7)
8) Null Voltage Measurements (see 4.2.2.8)
9) Vibration Test (see 4.2.2.9)

II Performance Tests (see 4.2.3)

1) Temperature Sensitivity Test (see 4.2.3.1)
2) Float Freedom Test (see 4.2.3.2)
3) 3 series of Servo Tests ("A" series) (see 4.2.3.3)
4) 24 hour storage at 135°F
5) 3 series of Servo Tests ("B" series) (see 4.2.3.3)
6) Shroud and Prealign (see 4.2.3.4)
7) 3 series of Servo Tests ("C" series) (see 4.2.3.3)
8) 24 hour storage at room temperature
9) 3 series of Servo Tests ("D" series) (see 4.2.3.3)
10) Torque-Angle Calibration Tests (see 4.2.3.5)

NOTE: In cases where the stability of the balance terms, ADIA and ADSRA, meet the stability requirements (paragraph 3.2.3.3) but exceed the magnitude requirements (paragraph 3.2.3.3) through the first two sets of servo tests (steps 3 and 5 above) the following variation to Performance Testing is allowed:

6) Rebalance

7) ~~Shroud and Prealign (see 4. 2. 3. 4)~~

8) 3 series of Servo Tests ("C" series) (see 4. 2. 3. 3)

9) 24 hour storage at room temperature

10) 3 series of Servo Tests ("D" series) (see 4. 2. 3. 3)

11) 24 hour storage at room temperature

12) 3 series of Servo Tests ("E" series) (see 4. 2. 3. 3)

13) Torque-Angle Calibration Tests (see 4. 2. 3. 5)

The test data from steps 3) and 5) must be submitted with the unit for acceptance.

3. 2. 2 Functional Requirements

The IRIG shall perform the following functions.

3. 2. 2. 1 Thermistor Calibration

The d-c resistance of each thermistor shall be 345 ± 34. 5 ohms at 135°F as measured per MC 25-800, current revision.

3. 2. 2. 2 Ducoysn Resistances (at 135°F)

(1) Suspension Circuits: 21 ± 3 ohms

(2) Signal Generator Primary Circuit: 9 ohms ± . 9 ohms

(3) Signal Generator Secondary Circuits: 77 ohms ± 7 ohms

(4) Torque Generator: 74. 5 ohms/winding ± 7 ohms
Demagnetize T. G. after resistance measurement per MC-25-828

3. 2. 2. 3 Magnetic Suspension Centering and Current Phasing

Connected as shown in Fig. 1 with each ducoysn's working capacitors (C_W) equal to each other within 1/2%, the S. G. and T. G. suspension currents shall lag their respective suspension voltage by 45 ± 3° (low side of the 10 Ω resistor). This measurement shall be made with the signal generator

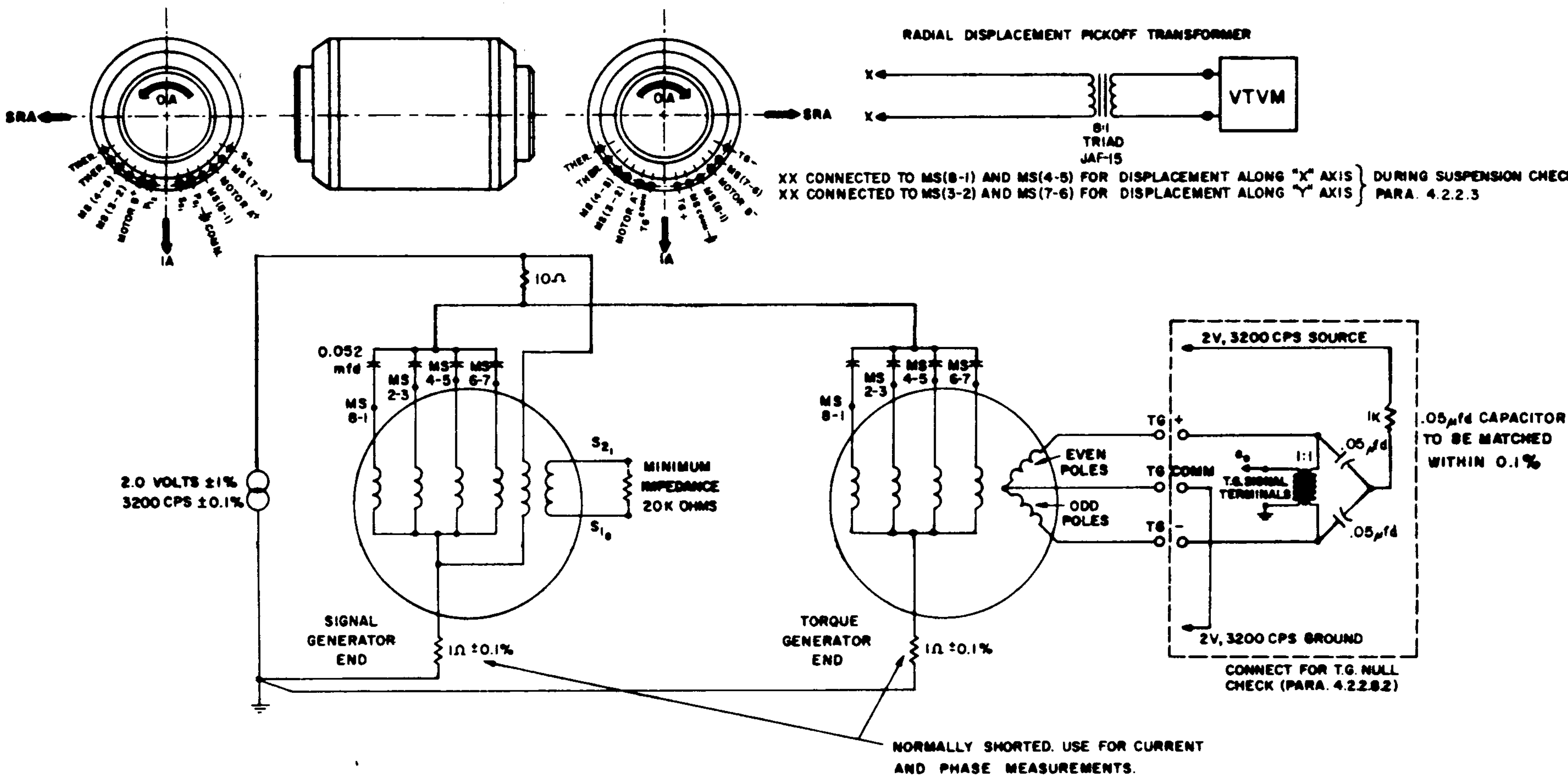

Fig. 1 APOLLO IRIG (ducosyn schematic)

primary disconnected and with the float suspended within the center half of the electrical range of the suspension.

3.2.2.4 Wheel Operation

(1) The spin motor shall be capable of reaching synchronous speed when excited with a voltage of 26.6 v maximum.

(2) The spin motor shall reach synchronous speed within 115 seconds maximum after application of normal 28 v excitation.

(3) The wheel run down time shall be measured, per MC 25-834, once at the beginning and once at the end of each servo test series. The rms deviation (σ_T) of the run down times to 6000 rpm obtained in these tests must be less than 5 seconds ($n \geqq 8$ for determination of σ_T).

3.2.2.5 Angle-Voltage Sensitivity

The average ratio of IRIG voltage output to Input Axis (IA) Angle, near null, shall be 11.8 ± 3.54 mv/mr.

3.2.2.6 Input Axis Polarity

Rotation in a positive IRIG IA direction should cause the voltage from S_{1_8} to S_{2_1} to have a phase of $0^\circ \pm 5^\circ$.

3.2.2.7 Limit of Equivalent Angular Rotation

An angular rotation of $.55^\circ$ to 1.2° about the IRIG IA from S.G. null, shall be sufficient to produce maximum angular displacement of the IRIG float about the Output Axis (OA).

3.2.2.8 Null Voltage Measurements

3.2.2.8.1 Signal Generator: Without compensation, the signal generator null voltage shall not be greater than 4 mv. (Signal

Generator null is the voltage output when the IRIG wheel is running and when the 3200 cps signal is minimum).

3.2.2.8.2 Torque Generator: The torque generator null when operated as a signal generator shall be within 1/2 mr of the signal generator null.

3.2.2.9 Vibration Requirements

The IRIG shall be capable of withstanding, without damage of any kind, 3 1/2 g rms sinusoidal acceleration along each of its principal axes, sweeping from 100 to 2000 cps.

3.2.3 Performance Tests

3.2.3.1 Temperature Sensitivity

At normal excitation and normal operating temperature with the OA up or down, the variation in gyro drift shall not be greater than 5 meru/$^{\circ}$F when subjected to a temperature cycle of 3°F at a rate between 1/2°F/minute and 1°F/minute.

3.2.3.2 Float Freedom

The performance requirements for the Float Freedom Test are as specified in paragraph 4.2.3.2.

3.2.3.3 Drift Rates

(1) With the excitation of 2 v ± 1%, the uncompensated bias drift rate (NBD), shall not be greater than 10 meru at any time.

(2) The acceleration-sensitive drift rate (ADIA) due to 1g of case acceleration along the positive Input Axis shall not be greater than 15 meru at any time.

(3) The acceleration-sensitive drift rate (ADSRA) due to 1g of case acceleration along the positive Spin Reference Axis shall not be greater than 15 meru at any time.

(4) The drift rate component proportional to the second power of the case acceleration along any axis shall not be more than 1 meru/g^2. (This is inherent in the design, if the wheel is assembled per MC 25-803, and is not a gyro test requirement).

(5) The standard deviation of the ten 1° points in any one of the four positions during any of the servo tests shall not exceed 3 meru.

(6) The greatest difference in NBD, ADIA, and ADSRA during preshroud testing shall not be greater than 5 meru. The greatest difference in NBD, ADIA and ADSRA after shrouding and prealigning shall not be greater than 5 meru.

3.2.3.4 Prealignment

3.2.3.4.1 Gyro Temperature Indication

The thermistor padding resistor shall be adjusted until the total thermistor resistance is $769.6\,\Omega \pm 1\,\Omega$ at 135°F.

3.2.3.4.2 Magnetic Suspension Current Phasing

The S.G. and T.G. magnetic suspension capacitors shall be adjusted until the suspension currents lag their respective suspension voltages by $45 \pm 3^{\circ}$.

3.2.3.4.3 Unit Alignment

The IRIG Input Axis shall be aligned to $35^{\circ} \pm 1'$ from the mounting flange slot.

3.2.3.4.4 Angle Voltage Sensitivity $(\frac{H}{C} S_{SG})$

The ratio of S.G. secondary output voltage to Input Axis angle shall be adjusted by varying the S.G. secondary resistor until a value of $8.3 \pm 0.207 \frac{mv}{mr}$ is attained.

3.2.3.5 Torque-Angle Calibration Test

The pulse rate shall be 3200 pps and the leading edge of the reset pulse shall lead the leading edge of the set pulse by 4.88 micro seconds.

The digital angle scale factor $M\Delta T/H$ shall be 0.00599 mr/pulse (2^{20} pulses/rev). The deviation in scale factor shall be less than 1000 ppm.

4. QUALITY ASSURANCE PROVISIONS

4.1 General

Unless otherwise specified herein, the supplier is responsible for the performance of all inspection requirements prior to submission for MIT/IL or NASA inspection and acceptance. Except as otherwise specified, the supplier may utilize his own facilities or any commercial laboratory acceptable to MIT/IL or NASA. Inspection records of the examinations and tests shall be kept complete and available to MIT/IL and NASA as specified in the contract or order.

4.1.1. Contractor's Quality Assurance Program

The contractor's quality assurance program shall be conducted in accordance with NASA Quality Assurance Documents 200.1, 200.2 and 200.3 and MIT Report R-349 to the extent specified in the procurement documents.

The Government reserves the right to perform any of the inspections set forth in this specification where such inspections are deemed necessary to assure that supplies and services conform to prescribed requirements.

4.1.2 Special Test Equipment (Test Turntable)

A special test turntable and associated equipment must be provided and must have provisions for operating the IRIG under conditions specified. Adequate meters must be provided to measure excitation levels and operating temperatures. The test table must have the following:

(1) Suitable mounting to assure that Gyro IA is - or can be adjusted to be - parallel to the test turntable axis within 1 mr (turntable axis wobble ± 0.1 mr).

(2) Provision for testing with the table axis vertical within 1 mr.

(3) Provision for testing with the turntable axis within 1 mr or horizontal and within 5 mr of north.

(4) Servo to keep gyro signal generator output signal inphase component below 2 mv and constant within .5 mv during gyro drift measurement runs.

(5) Angular velocity readout must provide timing signals for 1 degree angle increments with an accuracy of 5 seconds of angle or better for each increment.

(6) Angle increment timing during drift measurement tests must be accurate to 0.1 second time error or better.

(7) Wheel supply must be capable of delivering 15 w starting power.

(8) Table angle readout for ten degree increments shall have an accuracy of 5 seconds of arc or better for each increment.

4.2 Acceptance Tests

4.2.1 Test Conditions

Unless otherwise specified, the test procedures shall be accomplished under the following conditions:

Operating Temperature: $135^{o}F \pm 1/2^{o}F$ at the thermistors and stable within $\pm 0.1^{o}F$.

Flotation shall be $135^{o}F \pm 2^{o}F$ as measured at the thermistors.

Vibration: None (see Vibration Test, paragraph 4.2.2.9)

Humidity: Room ambient to 95% relative maximum humidity.

Microsyn Excitation: 2 v ± 1% at 3200 cps ± .1% This voltage is defined as having 0^{o} phase.

Suspension Excitation: 2 v ± 1% at 3200 cps ± .1%

Spin Motor Excitation: 28 ± 0.28 v, 800 ± 0.08 cps, two phase, A leading B by 90 ± 5^{o}.

4.2.2 Functional Tests

4.2.2.1 Thermistor Calibration

Before mass balance adjustment, the IRIG thermistors must be calibrated per M. C. #25-800, current revision.

4.2.2.2 Ducosyn Resistance Checks

The d-c resistance of each microsyn circuit must be measured with a suitable 20,000 ohm/volt ohmmeter. The resistances must be within the following limits:

(1) Suspension Circuits: 21 ± 3 ohms per leg at $135^{o}F$

(2) S.G. Primary Circuits: 9 ± .9 ohms at $135^{o}F$

(3) S.G. Secondary Circuits: 77 ± 7 ohms at $135^{o}F$

(4) T.G.: 74.5 ± 7 ohms/winding at $135^{o}F$

4.2.2.3 Magnetic Suspension Centering Test and Current Phasing Adjustment

4.2.2.3.1 Magnetic Suspension Centering Test (see MC25-842) For Detailed Procedure

Connect the microsyn to the test circuit as shown in Fig. 1 with the following exceptions:

Change 10 Ω to 50 Ω

Change .052 μfd to 1/2 power point plus .02 μfd

Change 2.0 volts to that necessary to achieve 35 ± 5 ma.

Test each suspension axis in the following manner: Record the radial rest voltages. Short, simultaneously, the appropriate capacitors to rotate the S.G. and T.G. ends of the float to diagonally opposite radial stops. Remove the short on the S.G. and immediately read the appropriate voltage and phase, replace the short and then repeat this procedure on the T.G. end. Repeat the test for all suspension axes (4 readings per end).

The two voltage readings per axis shall be of opposite phase.

These voltages shall decay to a stable reading within the center half of the range between the two readings (3:1 centering ratio).

4.2.2.3.2 Magnetic Suspension Current Phasing Adjustment

The S.G. and T.G. magnetic suspension capacitors (C_W) shall be adjusted until the suspension currents lag their respective suspension voltages by $45 \pm 3^{\circ}$ (low side of 10 ohm resistor to ground). The working capacitors at each end shall be equal within 1/2%.

4.2.2.4 Wheel Operation Test

Determine that the spin motor is capable of reaching synchronous speed at reduced voltage, as indicated by a sudden drop in wheel power, by applying a 26.6 v max, 800 ± 0.08 cps, two phase (A leading B) excitation. When this has been determined, remove the excitation and allow the wheel to stop.

To determine the time for the spin motor to reach synchronous speed, a normal exitation 28 ± 0.28 v is applied. The time required for the spin motor to reach synchronous speed is measured. This time should not exceed 115 sec.

After synchronization at normal excitation, the current level in each phase of the wheel circuit shall be measured and recorded.

The wheel rundown time shall be measured per MC 25-834.

Wheel rundown times will be measured once at the beginning and again at the end of each servo test series. (n = 8)

Record the rundown times.

The rms deviation (σ_T) of the rundown times to 6000 rpm obtained in those tests must be less than 5.0 sec.

4.2.2.5 Angle-Voltage Sensitivity Test

The turntable servo is disabled, the table axis is vertical, and the gyro is aligned IA parallel to table axis within 1 mr. The changes in the signal generator voltage are measured for approximately ± 1/4 degree of table motion caused by external means within 15 seconds of time. This motion should be such that the gyro signal generator passes through its null and reaches a value nearly equal to its starting value without hitting the gimbal stops. This will permit start and finish voltage readings to be read on the same meter scale. The sum of the meter readings is divided by the actual angle of rotation of the turntable expressed in mr.

This test is performed four times. Two readings in each direction of rotation are obtained. The average ratio of voltage change to angle change is computed.

The average ratio shall be 11.8 ± 3.56 mv/mr.

4.2.2.6 Input Axis Polarity Test

The turntable servo is disabled.

The turntable is rotated about its axis in a manner that drives the gyro gimbal alternately into each stop. A phase-meter is used to determine that the S_{1_8} to S_{2_1} voltage has a $0^{\circ} \pm 5^{\circ}$ phase angle when the turntable is rotated in positive IA direction.

The voltage readings are recorded at each stop position.

4.2.2.7 Limit of Equivalent Angular Rotation

The limits of equivalent angular rotation about the IA are computed by dividing the voltage reading at each stop position as obtained in the Input Axis Polarity Test (paragraph 4.2.2.6) by the average ratio of voltage change to angle change as computed in the Angle Sensitivity Test (paragraph 4.2.2.5). The result shall be from $.55^{\circ}$ to 1.2° at each stop.

4.2.2.8 Null Voltage Measurements Test

4.2.2.8.1 Signal Generator: The signal generator is connected to the loading network shown in Fig. 1.

The total rms null for the signal generator is measured using a sinusoidal-rms-calibrated average detecting VTVM.

The null shall not exceed 4 mv.

NOTE: The null may not be improved by loading or parallel input current to the signal generator in the Performance Test. Summation to the signal generator preamplifier output of voltage 90 ± 5° out-of-phase with the microsyn secondary voltage may be used to reduce servo amplifier null, if necessary.

4.2.2.8.2 Torque Generator: The rms voltage at the signal generator signal terminals is measured with the torque generator at null. (See Fig. 1)

The 3200 cps in-phase component of the signal generator angular voltage shall not exceed 6.5 mv.

4.2.2.9 Vibration Test

At operating temperature with the wheel running and microsyns excited, the unit should be subjected to 3-1/2 g rms sinusoidal acceleration sweep from 100 to 2000 cps at a constant logarithmic rate in a period of about 1 minute along each of the three principal gyro axes. The IRIG shall be capable of withstanding this test without damage of any kind.

Torque feedback from the signal generator to the torque generator should be supplied during the vibration as required to keep the gyro gimbal clear of its stops. No gyro performance need be measured during this step and temperature and excitations need be only approximately equal to specified values.

4.2.3 Performance Tests

4.2.3.1 Temperature Sensitivity Test

For this test, a continuous analog readout of drift is required. It may be provided by a torque-to-balance loop, previously standardized against the precision test turntable to within 5 meru. The torque-to-balance loop shall be calibrated against earth's rate for nominal torque generator sensitivity.

The Gyro OA is positioned approximately vertical and up. The operating temperature of the IRIG is varied ± $3^{o}F$ for at least three cycles at a rate of between $1/2^{o}F$/minute and $1^{o}F$/minute as indicated by the thermistors.

The cyclic variation of drift with temperature is observed.

The procedure above is repeated with the Gyro OA vertical and down.

The amplitude of the variation shall not exceed 5 meru/^{o}F. If the amplitude exceeds 5 meru/^{o}F, the IRIG is unacceptable, and further tests need not be conducted.

4.2.3.2 Float Freedom Test

The gyro shall be at Operating Temperature, mounted on a servo table with table axis vertical, and operated in a torque-to-balance mode as shown in the block diagram in Fig. 2.

4.2.3.2.1 Test Equipment Requirements:

a. The Float Rate Dummy Director shall be capable of supplying a properly phased 3200 cps ramp voltage output e_1 equal to 10 mv/minute ± 3.0 mv/minute and a linearity of ± 0.5% over a continuous voltage range from -50 mv (corresponding to positive float rotation about OA) to 0 mv and from 0 mv to + 50 mv (negative position about OA).

b. The torque recorder shall have a time constant of 1 sec maximum and shall have no provision for damping adjustment.

4.2.3.2.2 Calibration and Gain Adjustment of the Torque Feedback Amplifier

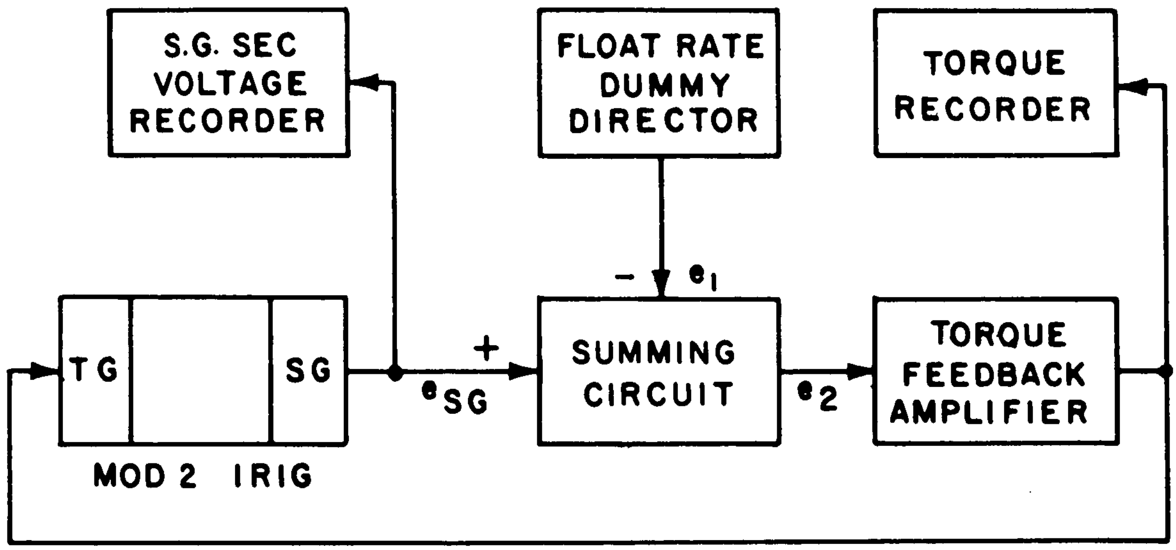

Fig. 2 Torque-to-balance mode block diagram

a. With the gyro positioned OA Vertical up, IA east, wheel off and loop closed, adjust e_1 to a phase of $180 \pm 2.0^{\circ}$ with e_{SG} at +50 mv. Set e_1 such that e_{SG} is at -50 mv and measure the phase of e_1 vs. e_{SG}. This phase angle shall be $180 \pm 2.0^{\circ}$. This procedure constitutes proper phasing as mentioned in paragraph 4.2.3.2.1a.

b. With the gyro positioned as in step a above, measure the loop null voltage e_2. Adjust e_1 to +25mv. After settling occurs, instantaneously switch e_1 to 0 mv and measure the time constant for e_1 to drop from 20 mv to the null. Adjust the Torque Feedback Amplifier gain until this time is between 3 and 5 sec. All testing in paragraphs 4.2.3.2.3 and 4.2.3.2.4 shall be done at this value of gain.

4.2.3.2.3 <u>OA Vertical Freedom Test:</u> The gyro shall be positioned OA Vertical up, IA east, and shall be normally excited except wheel off.

a. The Dummy Director signal e_1 shall be varied according to the schedule in Fig. 3. The float torque shall be continuously recorded throughout the forty minutes of testing. This will result in a torque trace which is shown idealized in Fig. 3. The tape speed shall be approximately 0.4 in./min.

b. Best Straight Lines, L, shall be drawn through the steady-state portions of the torque trace. These lines are defined by the average torque levels at 2 and 8 minutes after the beginning of each float rotation. The averaging shall be done over a 30 second interval about these times (Refer to Fig. 3)

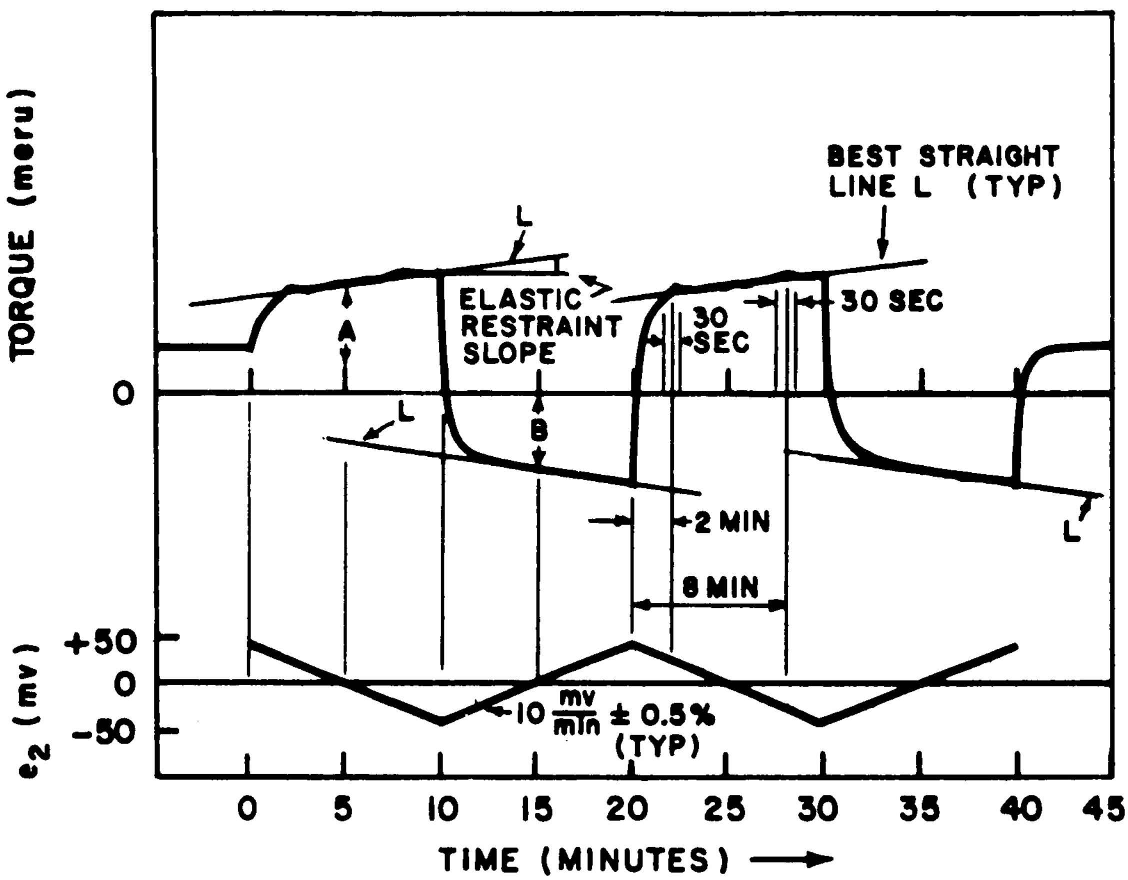

Fig. 3 Continuous Float rotation schedule.

c. Measure the slope of the Best Straight Line for the first direction of float rotation. This Elastic Restraint slope is shown in Fig. 3 and shall not exceed 3 meru/mv.

d. Observe all spikes and deviations from the Best Straight Line. No more than one spike or deviation may differ by more than 60 meru from its particular Best Straight Line level. The summation of all spikes or deviations greater than 15 meru from the Best Straight Line shall not exceed 90 meru.

e. The Dummy Director signal shall be varied according to the schedule in Fig. 4. This will result in a torque trace which is shown idealized in Fig. 4.

f. Intervals on the torque trace in which the Voltage rate is zero have been labelled C through J in Fig. 4. The average torque levels during the last minute of each of these 2 min intervals shall be algebraically subtracted as follows: C-J, D-I, E-H, and F-G. The absolute value of the difference between any of these terms shall not exceed 20 meru.

4.2.3.2.4 <u>IA Vertical Freedom Test</u>

The gyro shall be positioned IA Vertical up, OA South, and shall be normally excited except wheel off.

Repeat a, b, and d of paragraph 4.2.3.2.3 adhering to the same requirements.

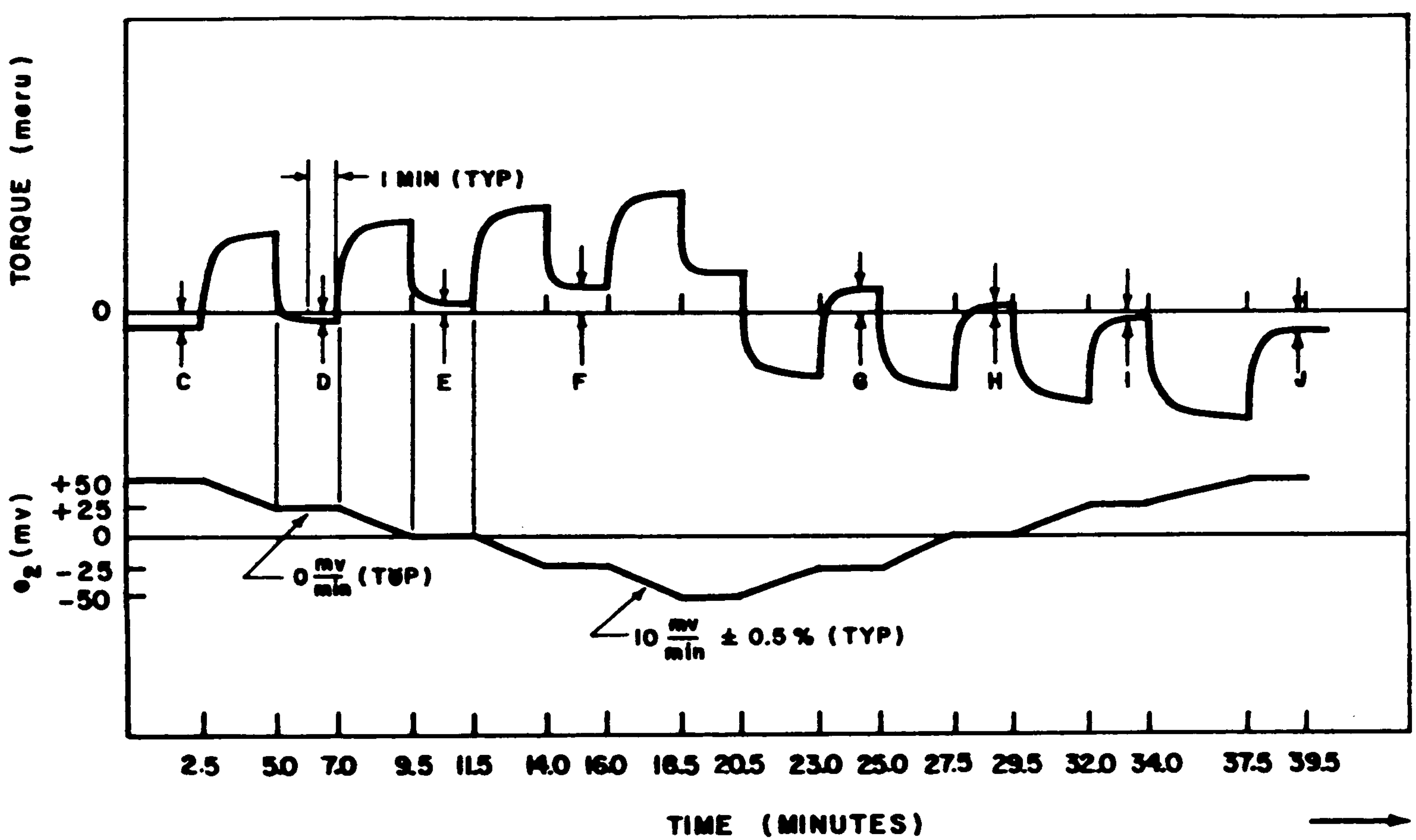

Fig. 4 Interrupted Float rotation schedule.

NOTE: It is advisable to measure each of the four suspension voltages at some time during the first direction of float rotation in both the OA Vertical and IA Vertical gyro orientations. These voltage levels can be compared with the suspension voltages measured during prolonged deviations on the torque trace. This comparison can be used to distinguish problems due to fluid contamination from those involving pivot-and-jewel clearance, endshake, etc.

4.2.3.3 Drift Tests

The following steps are to be performed prior to both "C" and "D" acceptance test series:

1. Unit must be at room temperature.

2. Gyro to be placed in $135^{o} \pm 5^{o}F$ oven for a minimum of one(1) hour, prior to mounting on servo table.

3. A maximum of two(2) hours may elapse between the time the unit is mounted on the table and the start of the "C" or "D" acceptance test.

4. The timer tapes for the acceptance test should be marked to indicate the time that the gyro was mounted on the table and the time that the test was started. These tapes should be made available when the gyro is submitted for acceptance.

4.2.3.3.1 Reduced Excitation Drift with Input Axis Up: With the test turntable axis vertical so that the positive direction of the Gyro IA will be up and at 1 v microsyn excitation, the turntable is allowed to rotate for a time interval during which the turntable should rotate more than 12^{o}.

Measure the total time for the turntable to rotate for the last 10 deg. Divide the total angle by the total time and convert to meru.

> NOTE: Note the direction of rotation of the test turntable. When looking down from the top of the test turntable, clockwise rotation will give negative meru values, counterclockwise rotation will give positive meru values of drift with respect to the Earth.

Add algebraically, to the meru value obtained above, +1000 times the sine of test station north latitude. The result of this addition is for the total uncompensated reduced excitation inertial space drift with 1 g of acceleration along the positive direction of the IA and is designated by the symbol Da.

4.2.3.3.2 Normal Excitation Drift with Input Axis Up: The procedure above (paragraph 4.2.3.3.1) is repeated with normal microsyn excitation of 2 v. The value of the computation is the total uncompensated normal excitation inertial space drift with 1 g of acceleration along the positive direction of the IA and is designated by the symbol Db.

4.2.3.3.3 Normal Excitation Drift with Spin Reference Axis Up: With the test turntable horizontal, the IRIG is aligned so that the positive direction of Gyro IA is north and the positive direction of the SRA is approximately vertically up. Excitation is the same as in paragraph 4.2.3.3.2.

Measure the time interval for consecutive 1^{o} angle increments of the test turntable for a total of 10 increments.

> NOTE: The test should be started with the SRA approximately 7^{o} toward the east away from vertical so that at the end of 12 increments, the SRA will be approximately 5^{o} away from vertical to the west.

Measure the total time for the turntable to rotate for the 10^{o} increments symmetrically about the vertical. Divide the total angle by the total time and convert to meru.

Observing the note (paragraph 4. 2. 3. 3. 1) for the sign of the meru value obtained above, add algebraically, +1000 times the cosine of the test station north latitude. The result of this addition is the total uncompensated normal excitation inertial space drift with 1g of acceleration along the positive direction of the SRA and is designated by the symbol Dc.

4. 2. 3. 3. 4 <u>Normal Excitation Drift with Spin Reference Axis Down</u>: The procedure above (paragraph 4. 2. 3. 3. 3) is repeated with the IA north but with SRA approximately vertical down and with the test started approximately 7^{o} toward the west away from the vertical. The excitation, computations, and plotting are the same as above (paragraph 4. 2. 3. 3. 3). The result is the total uncompensated normal excitation inertial space drift with 1g of acceleration along the negative direction of the SRA and is designated by the symbol Dd.

4. 2. 3. 3. 5 <u>Computation for the Total Acceleration Insensitive Normal Excitation Bias Drift Rate (NBD)</u>: The total acceleration insensitive normal excitation bias drift rate is the algebraic average value of Dc and Dd and is designated by the symbol NBD.

$$NBD = \frac{Dc + Dd}{2}$$

4. 2. 3. 3. 6 <u>Computation for the Acceleration Sensitive Drift Rate Due to 1g Acceleration Along the Positive Direction of the Input Axis (ADIA)</u>: The acceleration sensitive drift rate due to 1g acceleration along the positve direction of the IA is the algebraic subtraction of Db minus NBD and is designated by the symbol ADIA. That is:

$$ADIA = Db - NBD$$

4.2.3.3.7 Computation for the Acceleration Sensitive Drift Rate Due to 1g Acceleration Along the Positive Direction of the Spin Reference Axis (ADSRA): The acceleration sensitive drift rate due to 1g acceleration along the positive direction of the SRA is the algebraic average of the difference between Dc and Dd and is designated by the symbol ADSRA. That is:

$$\text{ADSRA} = \frac{\text{Dc} - \text{Dd}}{2}$$

4.2.3.3.8 Computation for Microsyn Excitation Sensitive Drift Rate (RD): The drift rate component which is proportional to the square of the microsyn excitation voltage is $\frac{4}{3}$ times the algebraic difference between the Normal and Reduced Excitation Drift rates (see paragraphs 4.2.3.3.1 and 4.2.3.3.2) and is designated by the symbol RD. That is:

$$\text{RD} = \frac{4}{3} (\text{Db} - \text{Da})$$

4.2.3.3.9 Computation for Independent Drift Rate(ID): The drift rate component which is independent of microsyn excitation or case acceleration is computed by the formula below and is designated by the symbol Id. That is:

$$\text{ID} = \text{NBD} - \text{RD}$$

4.2.3.3.10 Computation for the RMS Deviation of each Servo Test: The RMS deviation of the ten 1° drift rate values shall be calculated for each of the twelve servo tests. This computation shall be made by the following method:

$$\sigma_{10} = \sqrt{\frac{\sum_{i=1}^{i=10} (X_i - \overline{X})^2}{N}}$$

where X_i = drift rate at each of the ten 1^{o} points.

$\overline{X}$ = average drift rate of the ten 1^{o} points.

N = Number of points = 10

The RMS deviation σ_{10}, shall not exceed 3 meru.

4.2.3.4 Prealignment

The procedures to be followed for prealignment are specified in MC 25-837.

4.2.3.5 Command Angle Torque Test

This test shall be performed between the first and second sets of the series of Performance tests specified in paragraph 3.2.1 section II, items (5), (7) and (9).

(1) Demagnetize the TM+ and TM- windings.

(2) Orient the gyro IA vertically up.

(3) Set the compensation capacitor switches into the j and J positions.

(4) Preset the counter to 240 (40^{o}).

(5) Set the photocell amplifier into the CW position.

(6) Set the switches on the Gyro Control panel into the following position.

SWITCH	POSITION
Master - Production	Master
ON	ON
Gyro - Dummy	Gyro
TM+, TM-	TM+
Inertial - Caged	Inertial
P/C - N_2	P/C
Single - Repeat	Repeat

(7) Push the "Start" button on the Gyro Control panel.

(8) Increase the current slowly (this is accomplished by increasing the scale factor conductance bridge) until N+ (the counts for positive torquing) is obtained. Obtain five prints at this setting.

(9) Repeat steps 6, 7, and 8 with the TM+, TM- switch in the TM- position and the photocell amplifier in the CCW position to obtain N- (the counts for negative torquing).

In steps 8 and 9 as you approach the correct count level, adjust the compensation capacitors for a minimum pulse area when observing the transient between the scale factor resistor and the ground jacks on the front of the Gyro electronics drawer. If you do not overshoot the current setting to obtain the correct count, a second demagnetization will not be necessary.

(10) Record:

1. Torquer current using the current source monitor.
2. The voltage across the scale factor resistor using the current source monitor.
3. The scale factor resistor settings.
4. The compensation capacitor settings.

The above data shall be delivered with each gyro unit. The five counts at the N+ or N- level must agree with each other within 1000 ppm. The average of the five counts shall be within 500 ppm of the calculated N.

The number of counts for positive and negative torquing is given by:

$$N_{\pm} = \frac{174.53 \text{ mr}}{5.9921 \times 10^{-3} \pm \frac{WIE_V}{3200}}$$

where WIE_V is the vertical component of earth rate in mr/sec.

(11) If the data obtained from the three pulse torquing tests does not agree with each other within 1000 ppm, repeat items 1 to 10 of paragraph 4.2.3.5 to obtain two more sets of data that agree within 1000 ppm.

5. PREPARATION FOR DELIVERY

5.1 Delivery

A tag sheet, Fig. 5, shall be packed with each IRIG listing serial number and all other requested data. The last 20 hours of dynamometer trace for the wheel in each unit shall be included.

NOTE: When drift data is filled in on tag sheet, the tag sheet shall be classified as a CONFIDENTIAL document.

6. NOTES

6.1 Description (See Fig. 6)

The IRIG is a single degree of freedom gyro. Three IRIG's mounted on a stable platform maintain a reference for the nonrotating, space-oriented axes in the Apollo Guidance and Navigation System. The IRIG contains: a gyro wheel, a floated gimbal in which the wheel is mounted, a microsyn torque generator, and a microsyn signal generator, both generators being mounted on the floated gimbal axis. The spherical gimbal is immersed in a damping fluid of very carefully controlled viscosity, and the float axis is supported by a magnetic suspension at each end of the IRIG case.

DATA SHEET

FOR APOLLO 25 IRIG

Manufacturer ______________________ Serial Number________

Date of Acceptance Tests ______________________

A. Performance Characteristics

1. Temperature Sensitivity_______meru/$^{\circ}$F.

2. Maximum Float Friction ______meru.

3. Drift Parameters

a. Before Shrouding

Date	Test Station	Servo Run No.	NBD	ADSRA	ADIA	RD	ID
		A-1					
		A-2					
		A-3					
		B-1					
		B-2					
		B-3					

b. After Shrouding and Prealign

Date	Test Station	Servo Run No.	NBD	ADSRA	ADIA	RD	ID
		C-1					
		C-2					
		C-3					
		D-1					
		D-2					
		D-3					

Fig. 5-a

4. Maximum RMS Deviation (σ_{10})__________ meru.

B. Functional Characteristics

1. Thermistor Resistance at 135^{o}F__________ohms.
2. S. G. Suspension Capacitor __________mfd.
3. T. G. Suspension Capacitor __________mfd.
4. S. G. Angle Voltage Sensitivity__________ mv/mr.
5. RMS Deviation of RDT (σ_T)__________ seconds.
6. Total Wheel Time __________hours.
7. Average Rundown Time (A_T)__________ seconds.
8. Gyro Transfer Function __________mv/mr.
9. Total Temperature Indication Resistance __________ ohms.
10.

PULSE TORQUING DATA

		Average Count	Current (ma)	SF Resistor voltage (volts)	Compensation Capacitor	Conductance
B	TM+					
	TM-					
C	TM+					
	TM-					
D	TM+					
	TM-					

Fig. 5-b

[redacted]

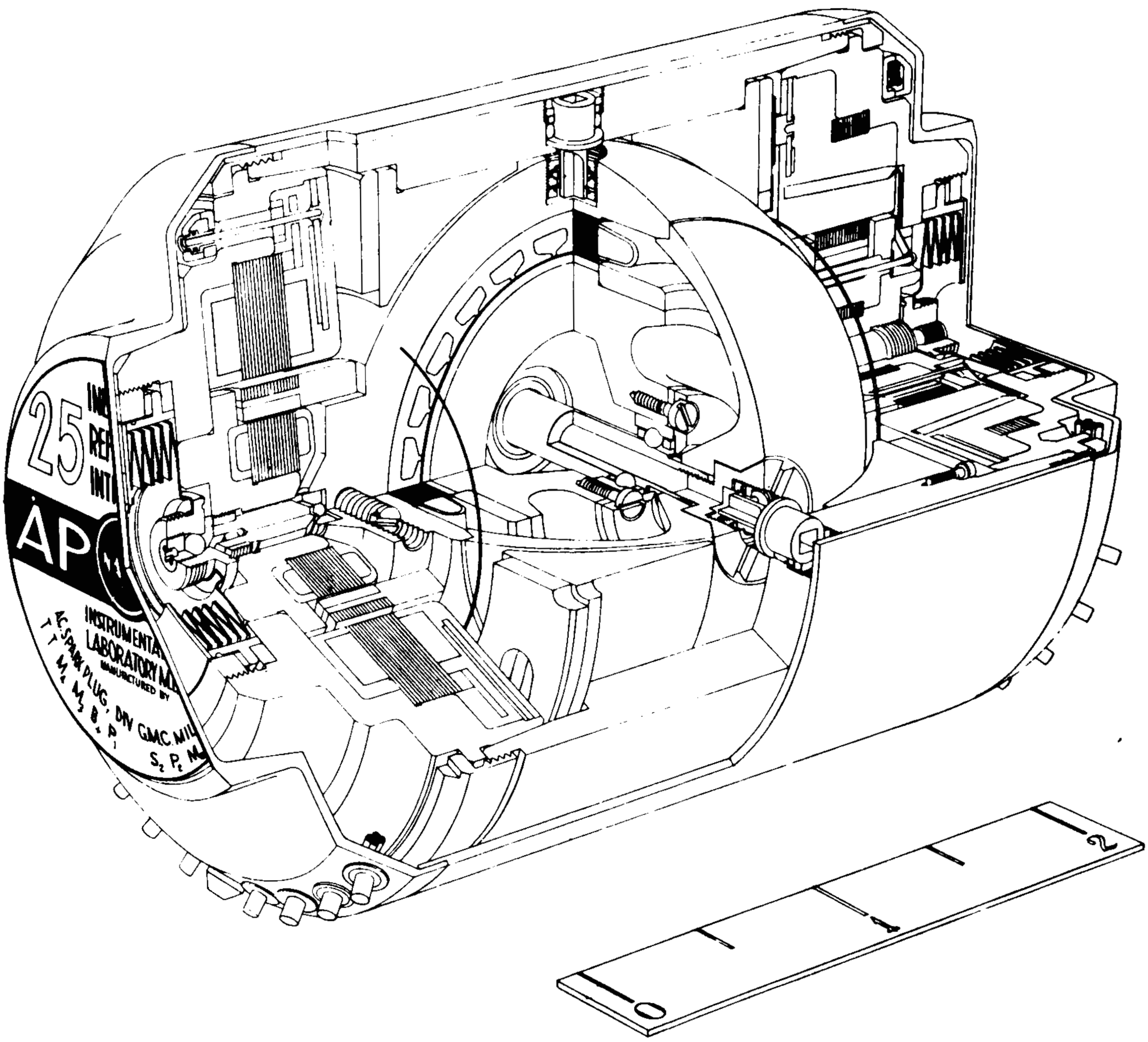

Fig. 6 25 Apollo IRIG(cutaway)

[redacted]

6.2 <u>Definitions of Symbols and Abbreviations. (All drift rates in meru with respect to inertial space.)</u>

σ_T	RMS deviation of Rundown Time (in seconds to 6000 rpm) from A_T.
$\bar{A}_F$	Average wheel rundown time (in seconds to 6000 rpm) measured at final float run-in during manufacture.
$\bar{A}_T$	Average wheel rundown time (in seconds to 6000 rpm) measured during acceptance test.
ADIA	Acceleration sensitive drift rate due to 1g of case acceleration along the positive IA Axis.
ADSRA	Acceleration sensitive drift rate due to 1g of case acceleration along the positive SRA Axis.
ID	Independent Drift Rate, independent of acceleration and microsyn excitation.
RD	Microsyn excitation sensitive drift rate in meru.
NBD	Normal excitation total bias drift rate (acceleration insensitive).
DNBD	The maximum difference of all NBD values.
DADIA	The maximum difference of all ADIA values.
DADSRA	The maximum difference of all ADSRA.
σ_{10}	RMS deviation of the ten 1° drift values in a Servo test.

R-348 Rev. B

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